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Combination of authenticity characteristics for high-value documents

The invention relates to a substance combination with two machine-checkable properties for verifying the authenticity of high-value documents, the use of this substance combination for verifying the authenticity of high-value documents, a high-value document with two authenticity characteristics with machine-checkable physical properties and a process for the manufacture of such high-value documents, as well as a process for checking the authenticity of carbonised material or ashes.

High-value documents in terms of this invention can be any documents which need to be protected against forgery. In particular, these include banknotes, share certificates, identification papers, but also identification cards, chip cards and similar. They can be manufactured on the basis of cellulose or cotton material or on the basis of plastic material or from a combination of several of these materials.

To protect the high-value documents against forgery, the high-value documents are provided with authenticity characteristics which cannot be counterfeited, or can only be counterfeited at disproportionately great expense. For example, fluorescent substances, magnetic particles and substances which can be detected on the basis of their specific physical properties can be used as authenticity characteristics. The term machine-checkable authenticity characteristics refers to characteristics which are, in particular, intended to be checked by machine, in contrast to characteristics which are to be checked by humans, especially visually. Such human characteristics include, for example, watermarks, guilloches, printed images produced by a photogravure process or similar. For example, magnetic materials are very suitable for machine checking. They can be added to the high-value document during manufacture in the form of magnetic particles. Such magnetic particles can be hard magnetic , i.e. they generate a permanent magnetic field after being magnetised, or they can be soft magnetic, i.e. they only display magnetisation under the influence of an external exciting magnetic field.

However, the use of luminescent markings as a machine-detectable authenticity characteristic is also known, in numerous forms, from the state of the art. A distinction is thereby made

between fluorescent substances, which only emit a characteristic emission radiation under exciting radiation, and phosphorescent substances, which also emit radiation over a longer period after the exciting radiation has been switched off. Different properties of the luminescent materials can be used as a proof of authenticity, for example excitation and emission spectra, visibility/invisibility of the emission, the duration of any afterglow and its half-value life, narrow/wide bandwidth of the emission. Security against forgery is additionally increased through these many analysis criteria, because the forger does not know which property is analysed and which he therefore has to reproduce.

Frequently, luminescent materials are used which only emit within a very narrow wavelength range, for example rare earth compounds. They have the advantage over wideband-emitting luminescent materials that their emission spectra are more characteristic than those of other substances, for which reasons they can be regarded as having a higher security value for machine-based authenticity verification. In order to increase the security value of wideband-emitting substances, their emission spectra can be transformed in a characteristic manner as described, for example, in DE 30 20 652.

For criminalogical purposes, it is helpful if characteristic substances are used for the safeguarding of documents which can still be identified even after the document has been burnt, to allow confirmation that an unrecognisable combustion residue actually originates from genuine documents. On the other hand, it must be made impossible for the characteristic substances contained in the ashes of burnt high-value documents to be recovered and used to create forgeries.

The objective of this invention is therefore to suggest a solution with which it should be possible to clearly identify a high-value document, both on the basis of the high-value document itself and also on the basis of its ashes, but without allowing illegal recovery of the authenticity characteristic for the purpose of reproducing high-value documents.

This problem is solved by means of the characteristics of the main claims. Further developments are disclosed in the subsidiary claims.

The invention is based on the finding that the conflicting objectives can be achieved by providing different physical or chemical properties which can be checked independently of one another and which change or disappear at different temperatures. Accordingly, the high-value document, as invented, features at least two machine-checkable physical or chemical properties which can be checked independently of one another, whereby the high-value document loses at least one machine-checkable property at a first temperature and possibly also the other checkable property at a second temperature which differs clearly from the first.

Preferably, the checkable properties are located in the same place and/or are based on the same physical or chemical phenomenon. Where these involve properties which are not based on the same physical phenomenon, they can be different properties of a single characteristic substance which at least partially disappear or change measurably at different temperatures. Preferably, two characteristic substances which each display one of the checkable properties are used.

Furthermore, according to the invention it should be taken into consideration in selecting the checkable properties that two temperature ranges are to be considered in connection with the burning of high-value documents. Firstly the specific combustion temperature, i.e. the temperature at which the high-value document, for example a banknote which is set alight with a cigarette lighter, burns under atmospheric conditions, and secondly the usual temperature at which the high-value documents are incinerated in high-temperature incinerators, because when they are no longer suitable for circulation due to their degree of soiling or damage, high-value documents are destroyed by the issuers in high-temperature incinerators with the assistance of oxygen or similar. The usual incineration temperature lies at around 1000°C or above. With values of between 400°C and 500°C, the specific combustion temperature lies well below the incineration temperature.

Since the incineration of high-value documents takes place in large quantities, according to the invention it must be ensured at all costs that unauthorised persons are unable to recover

authenticity characteristics from the combustion residues of the incinerated high-value documents which would allow counterfeiting of the high-value documents.

Accordingly, the checkable properties which can be used in accordance with the invention (E_1, E_2 etc.) must fulfil one of the following conditions, whereby T_1 refers to the specific combustion temperature and T_2 refers to the incineration temperature:

1st possibility:

The high-value document loses the first property E_1 below T_1 and retains the property E_2 above T_1 and T_2.

In this combination, it can be proved, on the basis of the temperature-stable checkable property E_2, that the ashes originate from a genuine high-value document. However, no conclusions can be drawn as to the nature of the combustion - combustion under atmospheric conditions or incineration.

2nd possibility:

The high-value document retains the properties E_1 and E_2 above the temperature T_1 and loses the property E_1 below the temperature T_2, while it also retains the property E_2 above T_2.

In this case, it is possible, on the basis of the property E_2, not only to determine that the ashes originate from a genuine high-value document, but also to determine the manner in which the high-value document was burnt, because if the ashes still display both properties E_1 and E_2, then the high-value document was burnt under atmospheric conditions, whereas if the ashes only display the property E_2, the high-value document was subjected to at least the incineration temperature.

3rd possibility:

The high-value document loses the property E_1 below T_1 and the property E_2 below T_2.

In this case, the ashes of a high-value document which was burnt at above the incineration temperature display neither the property E_1 nor the property E_2. The ash produced during the official incineration is thus neutral in terms of the characteristic properties. If, as before, the ash displays the property E_2, then this serves as proof that the burning took place under atmospheric conditions.

4th possibility:

The high-value document retains the properties E_1 and E_2 above T_1 and loses both properties below T_2.

Here too, it is possible to prove combustion under atmospheric conditions, so that accidentally burnt documents are, as before, recognised as true high-value documents and can, under certain circumstances, be exchanged for intact documents. If the ash displays neither property E_1 nor property E_2, then in this case no conclusion as to whether the high-value document was originally genuine is possible.

For the purpose addressed by the invention, a wide range of effects, such as luminescence, magnetism, conductivity or chemical reactions, can be used. The only important aspect in terms of the invention is that at least two physical or chemical properties can be evaluated, at least one of which is irreversibly changed or disappears above a certain first temperature and the second property is retained above the first temperature.

According to a preferred embodiment of the invention, the high-value document can be provided with two luminescent materials which lose their luminescent properties at different temperatures. Especially suitable are combinations of organic and inorganic luminescent

materials, since organic luminescent materials already lose their luminescent property at low temperatures, whereas numerous inorganic luminescent materials are temperature-stable.

Possible unstable organic luminescent materials include various different dyestuffs, such as methylene blue, rodamine, anthracene, chinazolone, benzozazine or similar, but also rare earth chelates or rare earth acetonates. Inorganic stable luminescent materials which can be used in accordance with the invention are rare-earth-doped host matrixes. Calcium wolframate, yttrium granate, yttrium vanadate, yttrium oxisulphide or similar are thereby used in preference as host matrixes. For invisible codings, the emission wavelength of which lies within the IR range, the rare earths neodymium, ytterbium, praseodymium, erbium or holmium are preferably used in chromiferous or ferrous host matrixes. The compounds containing rare earths are used in preference, because their emission bands are very narrow and are therefore very suitable for machine checking.

However, instead of the unstable organic luminescent materials, inorganic unstable luminescent materials such as silver- or copper/cerium-doped zinc sulphide can also be used.

According to a further embodiment of the invention, different magnetic materials can also be used which either irreversibly change, or completely lose, their magnetic behaviour at certain temperatures. Iron oxide (Fe_3O_4), black chromium oxide and barium ferrite are examples of temperature-stable magnetic substances with medium-hard to hard magnetic properties.

Less temperature stable, in contrast, are metallic magnetic materials such as iron or cobalt in powder form or in the form of thin layers. They display soft- to hard magnetic properties. Cobalt-iron or nickel-iron alloys are also soft magnetic and easily combustible. A further example of a very hard magnetic yet easily combustible material is cobalt samarium ($SmCo_5$).

Even at low temperatures, the easily combustible magnetic materials lose their magnetic properties completely or change their magnetic behaviour in a very characteristic way. In contrast, the magnetic properties of the temperature-stable magnetic materials remain unchanged.

If the high-value documents are documents in a series to which different countervalues are assigned - such as banknotes with different denominations for example - it can also be advantageous to provide the individual denominations with different pairs of properties, so that on examining the combustion residues it is possible not only to determine whether the documents were "genuine" or "fake", but also to determine the special category, e.g. the denomination of the high-value document. This would be particularly practical in the case of banknotes, since the denomination of the notes often cannot be determined from the combustion residues, while the owner wishes to prove that the ashes originate from particular banknotes.

The introduction of the characteristic substance can be achieved in different ways. If the high-value document consists of paper or includes a layer of paper, then the characteristic substances can be evenly mixed into the paper pulp during the manufacture of the paper or sprayed, printed or otherwise applied to or introduced into the finished, still-wet paper web, in specific areas.

If the high-value document includes plastic material, then the characteristic substances can also be added to the plastic material during the production of the plastic and processed into films or fibres together with this. These films or fibres can then be used as a high-value document or for the manufacture of high-value documents. It is also thereby possible to embed the film, cut into strips for example, into the paper as a security strip during the manufacture of the paper. It is also possible to apply the characteristic substances to security fibres or planchettes. Here too, as with the security strip, the materials can be introduced into the material of the security fibres or planchettes themselves or printed into the surface or dyed in together with the dye in a dye bath.

A further possibility involves the use of plastic films as a cover film for an identification card or pass.

Alternatively, the high-value document can also be printed with a printing ink containing the characteristic substance(s). However, the characteristic substances can also be contained in different printing inks. Any printing process can be used, in particular photogravure, thermal transfer printing, hot embossing or screenprinting.

The following examples are intended to briefly illustrate the range of possibilities.

Example 1

Two luminescent materials with differing emission spectra are mixed in with the paper pulp used for the manufacture of security paper before the sheets are produced. The temperature-stable luminescent material, in accordance with the invention, is $Y_3Al_5O_{12}$:Tb, which displays a highly characteristic emission spectrum in the green wavelength range. ZnS:CuCl is used as the less stable luminescent material; its emissions also lie within the green spectral range but disappear at temperatures of only 700°C. Although the emission spectra of the two luminescent materials both lie within the green spectral range, they differ so greatly in terms of the curve of their emission spectra that they can be identified, by technical means, separately from one another.

If the finished paper is ignited and burnt under normal atmospheric conditions, then both luminescent material remain detectable. Only when the paper is incinerated in an incinerator at above 1000°C is the less temperature-stable ZnS luminescent material destroyed. In contrast, the inorganic terbium-doped luminescent material also withstands these temperatures without damage, so that the ashes can be identified as originating from genuine documents on the basis of the characteristic spectrum of the $Y_3Al_5O_{12}$:Tb; however, it can also be determined from the ashes that they were not produced under normal atmospheric conditions.

Example 2

Two luminescent materials which display different emission spectra are mixed with a printing ink. The temperature-stable luminescent material is a zinc silicate:manganese (CD 12 produced by the company Allied Signal), which emits within the green wavelength range. A europium-chelate compound from the class of thenoyltrifluoroacetonates (CD 335 by Allied Signal) which fluoresces in the red wavelength range is used as the unstable luminescent material.

If the ink is applied to any given substrate, the mixed colour of the two fluorescent pigments is obtained as a visual impression. If the substrate is exposed to temperatures of over 800°C in an incinerator, the europium-chelate compound is destroyed. In contrast, the inorganic fluorescent material withstands this temperature without damage, so that the ash can be identified as originating from genuine documents on the basis of its characteristic fluorescence spectrum. However, at the same time it can also be proved that it was not produced under normal atmospheric conditions.

Example 3

An inorganic fluorescent material, yttrium oxide:europium (CD 106 by Allied Signal) together with an organic fluorescent material from the class of benzothiazoles (CD 333 by Allied Signal) with yellow-green fluorescence are mixed with an artificial resin matrix based, for example, on the polyaddition of several functional isocyantates, melamine and benzanide, during the plastic synthesis process. In this way a characteristic substance is obtained in the form of a powder which displays an orange fluorescence under UV excitation. If the luminescent pigment produced in this way is mixed with a printing ink and this is applied to paper, a paper with orange fluorescence is obtained. If the paper is exposed to temperatures of over 800°C in an incinerator, the organic fluorescent material is destroyed. In contrast, the inorganic fluorescent material withstands this temperature without damage, so that the ash can be identified as originating from genuine documents on the basis of its characteristic fluorescence spectrum. However, here too it can be proved that the ash was not

produced under normal atmospheric conditions. In this case the ash displays a red fluorescence.

Example 4

Two different offset inks are mixed, in one case with an inorganic fluorescent pigment, calcium silicate:maganese:lead (CD 110 by Allied Signal), which displays an orange fluorescence, and in the other with an organic pigment on the basis of anthranilic acid (CD 329 by Allied Signal), which displays a blue fluorescence. The printing inks obtained in this way are applied alternately as a coding to a film which is then cut into fine strips and used in the manufacture of paper as a security strip. If the high-value document marked in this way is exposed to temperatures of over 800°C in an incinerator, the organic fluorescent material is destroyed. In contrast, the inorganic fluorescent material withstands this temperature without damage, so that the ash can be identified as originating from genuine documents on the basis of its characteristic fluorescence spectrum. However, at the same time it can also be proved that it was not produced under normal atmospheric conditions. In this case the ash displays an orange fluorescence.

Example 5

In this case, one of the fluorescent materials used in example 4 is mixed into a printing ink and the other into the paper, as described in example 1. Following the application of the printing ink to the paper manufactured in this way, a document is obtained which displays an orange fluorescence in the print and a blue fluorescence in the paper. If the high-value document marked in this way is exposed to temperatures of over 800°C in an incinerator, the organic fluorescent material is destroyed. In contrast, the inorganic fluorescent material withstands this temperature without damage, so that the ash can be identified as originating from genuine documents on the basis of its

characteristic fluorescence spectrum. In this case the ash displays an orange fluorescence.

Example 6

A printing ink suitable for photogravure, tampography or silkscreen printing containing cobalt samarium powder ($SmCo_5$) is manufactured. For this purpose, 1 part vinylite, as a binding agent, is mixed with 1 to 2 parts magnetic pigment and 0.5 to 3 parts ethyl acetate as solvent. The quantity of the solvent depends on the printing process used. If the ink is printed using the photogravure process, more solvent is required, whereas less is required for silkscreen printing.

A second printing ink of the above composition is manufactured with carbonyl iron powder (99 % Fe). Both printing inks, possibly with the addition of further colour pigments, are printed as a barcode onto a plastic film which is then cut into security strips. These strips are completely embedded in the paper during manufacture.

This combination of cobalt samarium and carbonyl iron provides a high degree of security against counterfeiting, since it is not commercially available and displays highly characteristic magnetic properties. With a remanence of 40,000 Oe, cobalt samarium is extremely hard magnetic, whereas carbonyl iron only displays a remanence of less than 10 Oe.

When the high-value document is burnt under atmospheric conditions, the cobalt samarium is transformed into completely unmagnetic oxides and the carbonyl iron is transformed into iron oxides Fe_2O_3 and Fe_3O_4 with a significantly higher remanence, in comparison with carbonyl iron, of approx. 200 Oe to 400 Oe.

This means that the hard magnetic properties are lost through combustion, whereas the soft magnetic properties are retained, albeit in somewhat changed form.

Example 7

The magnetic pigments cobalt samarium and carbonyl iron named in example 6 can also be mixed with offset, typographic or steel engraving inks. For this purpose, 0.3 parts magnetic pigment and 1 part linseed oil varnish are mixed. Depending on the printing process, the varnish is thereby applied in thinner (offset) or thicker (steel engraving) form using more or less linseed oil.

Using these printing inks, a high-value document is printed with various characters or patterns, either in the same position or in different places.

The checking of carbonised or burnt material supposed to originate from high-value documents in terms of the invention is carried out on the basis of the checkable physical or chemical properties of the characteristic substance. The checkable property is thereby analysed by machine and compared with stored reference values. If a high-value document has allegedly been accidentally burnt under atmospheric conditions, the measured values for the checkable property are compared with the expected reference values for the temperature range above approx. 400 to 500°C and below approx. 1000°C. Only if the measured values correspond with the reference values is the high-value document genuine.

At the same time, it can be proved whether the supposed high-value document was actually burnt under atmospheric conditions. If the reference values match up with the reference values above the incineration temperature of approx. 1000°C, then this can be an indication that ash has been removed with fraudulent intent from an incineration process and declared to be an accidentally burnt high-value document in order to have this exchanged by the issuer for an intact high-value document.

In order to make the identification of the ash even more reliable, the characteristic substances or characteristic components of the characteristic substances can be detected with the aid of trace analysis methods and their concentration determined. Methods such as atomic absorption spectroscopy (AAS), atomic emission spectroscopy (AES) within the discharge spectrum or electron-beam analysis (EBMA), for example, are suitable for this purpose.

The characteristic substances which are not found in the ashes of documents which are not protected in accordance with the invention are, in particular, detected by means of these trace analysis methods. In the example 1 described above, the materials yttrium, terbium, zinc and copper and the concentration ratios of these substances are analysed. In example 7, on the other hand, the presence of the substances iron, cobalt and samarium is detected and the relative concentration ratios of these substances analysed.

Claims

1. High-value document, such as a banknote, identification card or similar,
   - with at least one first machine-checkable physical or chemical property and
   - with at least one second machine-checkable physical or chemical property,

   whereby
   - both physical or chemical properties are from at least one characteristic substance,
   - the first and second checkable property can be checked by machine separately from one another,
   - the characteristic substance loses the first machine-checkable property, or the property changes measurably, at a first temperature, and
   - the characteristic substance retains the second checkable property at the first temperature and possibly loses it at a second temperature which differs clearly from the first.

2. High-value document in accordance with claim 1, characterised in that the first and second checkable property can be machine-checked in the same position, but separately from one another.

3. High-value document in accordance with claim 1 or 2, characterised in that the checkable properties are based on the same physical effect.

4. High-value document in accordance with at least one of claims 1 to 3, characterised in that the high-value document features at least a first and second characteristic substance which posses the first and second physical properties respectively.

5. High-value document in accordance with at least one of claims 1 to 3, characterised in that the first temperature is lower than or equal to the specific combustion temperature of the high-value document.

6. High-value document in accordance with at least one of claims 1 to 4, characterised in that the first and/or second temperature is greater than the specific combustion temperature of the high-value document.

7. High-value document in accordance with at least one of claims 1 to 4, characterised in that the first and/or second temperature is greater than the specific combustion temperature of the high-value document, but less than an incineration temperature.

8. High-value document in accordance with at least one of claims 1 to 4, characterised in that the second temperature is greater than an incineration temperature of the high-value document.

9. High-value document in accordance with at least one of claims 1 to 8, characterised in that the specific combustion temperature of the high-value document is 400°C to 600°C, preferably approx. 500°C

10. High-value document in accordance with at least one of claims 1 to 9, characterised in that the incineration temperature is 1000°C or above.

11. high-value document in accordance with at least one of claims 1 to 10, characterised in that the first characteristic substance is an inorganic luminescent material and the second characteristic substance is an organic luminescent material.

12. High-value document in accordance with claim 1, characterised in that the organic luminescent material is methylene blue.

13. High-value document in accordance with at least one of claims 1 to 10, characterised in that the first and second characteristic substances are each inorganic luminescent materials.

14. High-value document in accordance with at least one of claims 1 to 13, characterised in that the inorganic luminescent materials contain rare-earth-doped host matrixes.

15. High-value document in accordance with one of claims 1 to 14, characterised in that at least one of the checkable properties is included on or in a security strip or security fibre.

16. High-value document in accordance with one of claims 1 to 15, characterised in that at least one of the checkable properties is contained in at least one printing ink which is printed onto the high-value document.

17. High-value document in accordance with one of claims 1 to 16, characterised in that at least one of the checkable properties is contained in the basic material of the high-value document.

18. High-value document in accordance with one of claims 1 to 17, characterised in that the basic material of the high-value document essentially consists of paper, preferably cotton paper.

19. High-value document in accordance with one of claims 1 to 17, characterised in that the basic material of the high-value document essentially consists of a plastic material.

20. Substance combination for verifying the authenticity of high-value documents with

- a first characteristic substance with a first checkable physical property and
- a second characteristic substance with a second checkable physical property

whereby

- the first and second checkable property can be checked separately from one another,
- the first characteristic substance loses the first checkable property at a first temperature, and

- the second characteristic substance retains the second checkable property unchanged at the first temperature but possibly loses it at a second temperature which differs clearly from the first.

21. Substance combination in accordance with claim 20, characterised in that the first and second checkable property are based on the same physical phenomenon.

22. Substance combination in accordance with claim 20 or 21, characterised in that the first characteristic substance is an inorganic luminescent material and the second characteristic substance is an organic luminescent material.

23. Substance combination in accordance with claim 22, whereby the organic luminescent material is methylene blue.

24. Substance combination in accordance with claim 20 or 21, characterised in that the first and second characteristic substances are each inorganic luminescent materials.

25. Substance combination in accordance with at least one of claims 22 to 24, characterised in that the inorganic luminescent materials comprise rare-earth-doped host matrixes.

26. Substance combination in accordance with claim 25, characterised in that the rare earth is selected from the group of substances neodymium, ytterbium, praseodymium, erbium and holmium.

27. Substance combination in accordance with claim 25 or 26, characterised in that the host matrix contains substances selected from the group chromium and iron.

28. Substance combination in accordance with claim 24, characterised in that the second luminescent material is ZnS:CuCl and the first luminescent material is $Y_3Al_5O_{12}$:Tb.

29. Use of a substance combination in accordance with at least one of claims 20 to 28 for verifying the authenticity of high-value documents.

30. Process for the manufacture of high-value documents in accordance with at least one of claims 1 to 20, characterised in that the first and second checkable property are permanently associated with the high-value document.

31. Process in accordance with claim 30, characterised in that the high-value document is provided with a first and second characteristic substance which display the first and second checkable property respectively.

32. Process in accordance with claim 31, characterised in that at least one of the characteristic substances is introduced as an additive into a security strip, security fibres or the material of the high-value document.

33. Process in accordance with claim 31, characterised in that at least one of the characteristic substances is mixed with a printing ink and printed onto the high-value document.

34. Process in accordance with at least one of claims 30 to 33, characterised in that the first and second characteristic substances are processed as a mixture of substances.

35. Process for checking carbonised or burnt material supposed to originate from a high-value document in accordance with at least one of claims 1 to 19, characterised by the following steps:

- Determination of the temperature to which the high-value document was exposed,
- checking of the physical properties
- calling-up of stored reference values depending on the temperature to which the high-value document was exposed,
- comparison of the reference values with the measured values.

Abstract

The invention relates to a high-value document, such as a banknote, identification card or similar, with a first machine-checkable physical or chemical property and with a second machine-checkable physical or chemical property, whereby the first and second checkable property can be checked by machine separately from one another, the high-value document loses the first checkable property at a first temperature, and the high-value document loses the second checkable property at a second temperature which is different from the first.